

TITLE OF THE INVENTION

SUB-SCANNING INTERVAL ADJUSTING APPARATUS FOR MULTI-BEAM SCANNING UNIT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 2002-49961, filed August 23, 2002, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

[0002] This application is a continuation-in-part of U.S. Serial No. 10/437,185, filed May 14, 2003, currently pending.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0003] The present invention generally relates to a multi-beam scanning unit used in an image forming apparatus, such as a laser printer, and more particularly, to a sub-scanning interval adjusting apparatus of a multi-beam scanning unit adjusting a distance between at least two beams of the multi-beam scanning unit.

2. Description of the Related Art

[0004] Generally, a laser printer forms an image by processes of focusing a laser beam from a laser scanning unit onto a photoreceptor drum in accordance with a video signal, developing an electrostatic latent image on the photoreceptor drum, and transferring the developed image onto a printing medium such as a paper. An exemplary structure of the laser scanning unit for use in the laser printer is shown in FIG. 1.

[0005] Referring to FIG. 1, the laser scanning unit is provided with a laser source 10, a collimating lens 11, a cylinder lens 12, a polygon mirror 13, an f-theta lens 15, and a reflective mirror 16.

[0006] The laser source 10 generates a laser beam 1, and usually a laser diode is used as the laser source.

[0007] The collimating lens 11 transforms the laser beam 1 from the laser diode 10 into a parallel or convergence ray of light (laser beam 1 having parallel rays) with respect to an optical axis.

[0008] The cylinder lens 12 focuses the laser beam 1 passed through the collimating lens 11 onto a surface of the polygon mirror 13 in a form of a line in a horizontal direction.

[0009] The polygon mirror 13 is rotated by a motor 14 at a constant speed to perform scanning by displacing the laser beam 1 passed through the cylinder lens 12 with a constant linear velocity in the horizontal direction.

[0010] The f-theta lens 15 has a predetermined refractivity with respect to the optical axis, deflects the laser beam 1 reflected from the polygon mirror 13 at constant velocity towards the main scanning direction (arrow A), and compensates for aberrations, thereby focusing the laser beam 1 on the scanning surface.

[0011] The reflective mirror 16 reflects the laser beam 1 passed through the f-theta lens 15 towards a certain direction, thereby focusing the laser beam 1 on a surface of a photoreceptor drum 17 in a form of a dot.

[0012] Further provided is an optical sensor 19 for horizontal-synchronizing the laser beam 1. The optical sensor 19 is provided with a synchronization signal detecting reflective mirror 18, which reflects the light passed through the f-theta lens 15 towards the optical sensor 19.

[0013] The above-mentioned components are assembled in a single frame (not shown) to form the laser scanning unit. Further, a transparent glass member (not shown) is attached to an outer side of the frame to prevent foreign substances, such as dust, from being introduced into the laser scanning unit.

[0014] Increasingly, demands on the laser printer that prints at a higher printing speed have been growing. In order to increase the printing speed of the laser printer, a scanning speed of the polygon mirror 13 needs to be increased. And in order to increase the scanning speed, an R.P.M of the motor 11 has been increased to increase the R.P.M of the polygon mirror 13. This way, however, has been accompanied by problems, such as an increase of noise, and also a high material cost mainly due to the requirement for a high-speed motor.

[0015] In an attempt to solve the above-mentioned problems, recently employed is a multi-beam scanning unit that has a plurality of light sources. In this case, if the multi-beam scanning unit having two light sources is employed to guarantee the constant printing speed, the motor 14 for the polygon mirror 13 has a half R.P.M of a general motor.

[0016] With the multi-beam scanning unit, two lines of a given resolution are simultaneously formed on the photoreceptor drum 17 in a perpendicular direction (hereinafter called 'sub-scanning direction') in relation to the main scanning direction.

[0017] In the meantime, when components of the laser scanning unit are assembled, errors inevitably occur due to assembling status or precision of the respective components.

[0018] Accordingly, a space interval between two lines in the sub-scanning direction is deviated from a normal interval that is predetermined for the corresponding resolution. And this usually causes an undesired phenomenon, so-called 'jittering', in the laser printer with high-resolution, deteriorating a sharpness of a printing image.

[0019] In order to solve the above-mentioned problems, as shown in FIG. 2, an apparatus 20 is provided to adjust an interval between multi-beams in the sub-scanning direction.

[0020] Referring to FIG. 2, the multi-beam interval adjusting apparatus 20 includes a substrate 21 and a sub-assembling plate 23.

[0021] The substrate 21 is mounted with a laser diode 22 as a light source, and a circuit driving the laser diode 22. The sub-assembling plate 23 has a lens barrel 23-1 formed at a center thereof, and a plurality of elliptical holes 23-3 allowing the sub-assembling plate 23 to rotate about the lens barrel 23-1 by a predetermined angle. Assembled in the lens barrel 23-1 is a collimating lens 24. A tap hole 23-2 is formed on the sub-assembling plate 23 to secure the substrate 21 on the assembling plate 23. The substrate 21 is assembled with respect to the sub-assembling plate 23 by screws 26 through screw holes 21-1. Then, after the lens barrel 23-1 of the sub-assembling plate 23 is inserted in a hole 25-1 formed on the frame 25, the sub-assembling plate 23 is fastened to the frame 25 with screws 27. The screws 27 are fastened to the frame 25 through the elliptical holes 23-3 of the sub-assembling plate 23 and screw holes 25-2 of the frame 25. Accordingly, the lens barrel 23-1 of the sub-assembling plate 23 is adjustable in a precise position with respect to the hole 25-1 of the frame 25.

[0022] Accordingly, when laser light (a laser beam) is emitted from the laser diode 22, the laser beam passes through the lens barrel 23-1 and is incident on the collimating lens 24 and concentrated thereon in a form of a parallel ray.

[0023] In a case that the two lines of the laser beam concentrated on the photoreceptor drum 17 in the sub-scanning direction are disposed at an interval while being deviated from a

predetermined interval, such deviation is adjusted by minutely moving and fastening the sub-assembling plate 23 on the frame using the screws 27.

[0024] However, the multi-beam interval adjusting apparatus 20 as described above has a shortcoming. That is, the image formation of the two laser lines in the scanning direction starts from different positions. By way of one example, FIG. 3A shows two laser diodes 22-1, 22-2 that are provided on the same line and in perpendicular relation with respect to the scanning direction, and at a predetermined interval (p). As are predetermined, the two lines are formed on the photoreceptor drum 17 at the predetermined interval (p). Then when the two lines are formed at an interval other than the predetermined interval (p), such deviation is adjusted by adjusting the interval between the laser diodes. Accordingly, the sub-assembling plate 23 is rotated to adjust the interval between the two lines as predetermined. However, while the interval between the two laser diodes 22-1, 22-2 in the sub-scanning direction becomes p' , the laser diodes 22-1, 22-2 are deviated from a predetermined plane in the main scanning direction by a distance (Δ) (see FIG. 3B). As a result, the image formation in the scanning direction starts differently. Such a problem can be solved by employing a software or device for compensation.

[0025] However, employment of the compensation software or device causes a structure of the laser scanning unit to be complex, and a material cost increases.

SUMMARY OF THE INVENTION

[0026] Accordingly, it is an aspect of the present invention to provide a sub-scanning interval adjusting apparatus of a multi-beam scanning unit adjusting an interval in a sub-scanning direction between two lines of laser light with ease without having deviation of starting positions of the laser light of image formation in a scanning direction.

[0027] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0028] In order to accomplish the above and/or other aspects of the invention, a sub-scanning interval adjusting apparatus of a multi-beam scanning unit adjusts an interval between at least two laser beams using the laser beams being simultaneously emitted from the at least two laser sources of the multi-beam scanning unit and includes a transparent member arranged

on an optical path of the laser beams to adjust the interval between the laser beams.

[0029] The transparent member varies in thickness depending on its height in a direction where the laser beams pass through, and is either a triangle or a trapezoid in cross-section in the direction where the laser beams pass through.

[0030] According to another aspect of the present invention, a sub-scanning interval adjusting apparatus of a multi-beam scanning unit adjusting an interval between at least two laser beams uses the laser beams being simultaneously emitted from the at least two laser sources of the multi-beam scanning unit and includes a transparent member varying in thickness depending on its height in a direction where the laser beams pass through, and a movable member adjusting the transparent member in height. Accordingly, the interval between the laser beams is adjusted by adjusting the height of the transparent member with respect to the laser sources using the movable member.

[0031] According to another aspect of the present invention, an elastic member is formed on the transparent member to press the transparent member.

[0032] According to another aspect of the present invention, a sub-scanning interval adjusting apparatus of a multi-beam scanning unit adjusting an interval between at least two laser beams uses the laser beams being simultaneously emitted from at least two laser sources of the multi-beam scanning unit and includes a transparent member varying in thickness depending on its height in a scanning direction where the laser beams pass through, the transparent member having an inclined lower side towards the scanning direction of the laser beams, and a movable member having an inclined side corresponding to the inclined lower side of the transparent member. Accordingly, the interval between the laser beams is adjusted when the movable member moves towards the scanning direction and thus adjusts the height of the transparent member with respect to the laser sources.

[0033] According to another aspect of the invention, the transparent member is triangular or trapezoidal in cross-section in the direction where the laser beams pass through. The transparent member has an optical refractivity great than 1.

[0034] With a sub-scanning interval adjusting apparatus for a multi-beam scanning unit according to the present invention, an interval between a plurality of laser beams in a sub-scanning direction can be easily adjusted without causing starting points of image formation in a

scanning direction to be deviated from each other. Since there is no need to employ software or a device to compensate for the deviation of the image formation starting points, construction of the scanning unit becomes simplified, and a cost of a material is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a view showing a structure of a conventional scanning unit;

FIG. 2 is an exploded perspective view of an apparatus for adjusting an interval in a sub-scanning direction for the conventional multi-beam scanning unit of FIG. 1;

FIGS. 3A and 3B are views showing deviations in starting points of image formation due to an interval adjustment of the interval adjusting apparatus of FIG. 2;

FIG. 4 is a view showing an apparatus for adjusting an interval in a sub-scanning direction for a multi-beam scanning unit according to an embodiment of the present invention;

FIG. 5 is a side view of the interval adjusting apparatus of FIG. 4;

FIG. 6 is a view showing a change in an optical path of a laser beam passing through a transparent member of the interval adjusting apparatus of FIG. 4;

FIG. 7A is a view showing a change in the optical path of two parallel laser beams passing through the transparent member of the interval adjusting apparatus of FIG. 4;

FIG. 7B is a view showing a change in the optical path of two non-parallel laser beams passing through the transparent member of the interval adjusting apparatus of FIG. 4;

FIG. 8 is a view showing another apparatus for adjusting an interval in a sub-scanning direction for a multi-beam scanning unit according to another embodiment of the present invention;

FIG. 9 is a side view of the interval adjusting apparatus of FIG. 8; and

FIG. 10 is a view showing a structure of a multi-beam scanning unit according to an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0036] Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described in order to

explain the present invention by referring to the figures.

[0037] Hereinafter, the present invention will be described in detail with reference to the accompanying drawings. Referring to FIGS. 4 and 5, a sub-scanning interval adjusting apparatus 100 for a multi-beam scanning unit according to an embodiment of the present invention includes a transparent member 110, a movable member 120 and an elastic member 130.

[0038] The transparent member 110 is made of a material, such as glass or plastics, through which a laser beam passes. The transparent member 110 is generally formed by injection molding. The transparent member 110 has a predetermined optical refractivity, and it is possible that the refractivity is more than 1. A cross-section of the transparent member 110 may vary in thickness in accordance with a height direction, i.e., a direction (a sub-scanning direction as indicated with an arrow C) perpendicular to a laser scanning direction as indicated with an arrow B. It is possible that a lower portion is thicker while an upper portion is thinner. FIG. 5 shows one example of a structure of the transparent member 110 in section, which has a shape of a trapezoid. Alternatively, the transparent member 110 may be a triangle in cross-section. The transparent member 110 has a lower side 111 formed at a predetermined angle with respect to a lengthwise direction (the arrow B), i.e., the scanning direction.

[0039] The movable member 120 has an upper side 121 formed at an angle corresponding to the angle of the lower side 111 of the transparent member 110. The upper side 121 of the movable member 120 is slidable with respect to the lower side 111 of the transparent member 110. The movable member 120 is also provided with a driving unit (not shown) moving the movable member 120 leftward and rightward, i.e., in the scanning direction (the arrow B). Accordingly, as the movable member 120 is moved leftward and rightward, the transparent member 110 is moved upward and downward (the arrow C).

[0040] The elastic member 130 is placed on the transparent member 110, pressing the transparent member 110 with a predetermined pressure with respect to the movable member 120. Being secured in a certain position of a frame 135 of a scanning unit, the elastic member 130 also serves to secure the transparent member 110 at a certain position in an optical path of the laser beam. The elastic member 130 is made of any material that has a flexibility, and a compression spring may be used as the elastic member 130.

[0041] The sub-scanning interval adjusting apparatus 100 may be placed in any position on

the optical path of the laser beam, i.e., from the laser source of the multi-beam scanning unit to the surface of the photoreceptor drum 17, so long as it is located within a range that enables adjustment of interval between at least two laser beams. Also, as shown in FIG. 10, the sub-scanning interval adjusting apparatus 100 may be placed between the f- θ lens as an image focusing lens on the one hand and the photoreceptor drum 17 as a photoreceptor medium on the other hand.

[0042] An operation of the sub-scanning interval adjusting apparatus for the multi-beam scanning unit having the above structure, will be described below.

[0043] When two laser lines are concentrated (formed) on a photoreceptor drum 17 (FIG. 1) at an interval deviated from the predetermined interval, by driving the driving unit, the movable member 120 is moved leftward or rightward, i.e., in the scanning direction (the arrow C). If the movable member 120 is moved rightward, the transparent member 110 is moved upward by sliding along the inclined lower side 111. If the movable member 120 is moved leftward, the transparent member 110 is moved downward by sliding along the inclined lower side 111, and the downward movement of the transparent member 110 is carried out easily by a recovering force of the elastic member 130. As the transparent member 110 is moved upward and downward with respect to the optical path of the two laser beams, the optical path changes by the transparent member 110, and as a result, the interval between the two laser lines can be adjusted.

[0044] A principle of adjusting the interval between the two laser lines through the upward and downward movement of the transparent member 110 will be described below in greater detail.

[0045] FIG. 6 shows a process in which the optical path of the laser beam incident on the transparent member 110 changes as the laser beam passes through the transparent member 110. The laser beam passing through the transparent member 110 satisfies the following equation of the Snell's law.

Equation 1

$$\sin \theta 1 = n \cdot \sin \theta 2$$

where n is a refractivity of the transparent member 110, $\theta 1$ is an angle of the laser beam being incident on the transparent member 110 with respect to a surface perpendicular to an incident surface 110a of the transparent member 110, and $\theta 2$ is an angle of the laser beam having been

incident on the transparent member 110 with respect to the surface perpendicular to the incident surface 110a of the transparent member 110.

[0046] In FIG. 6, an upper laser beam of two laser beams emitted from two laser diodes is indicated as a laser beam ①, while a lower laser beam is indicated as a laser beam ②. An interval between the two incident laser beams ①, ② is L . When the optical path leads the two laser beams ①, ② through the transparent member 110c having a uniform thickness, the interval between the laser beams ①, ② emitted from the transparent member 110c is as much as L . However, when the optical path leads the two laser beams ①, ② through the transparent member 110b having a variable thickness, the interval between the two laser beams ①, ② emitted from the transparent member 110b is changed from L to L' . This is because of different optical distances of optical paths of the two laser beams ①, ② with respect to the a plane 110c parallel to the incident surface 110a of transparent member 110, and an exit surface 110b. An optical distance is obtained by multiplying the refractivity n of a medium by a thickness d of the medium.

[0047] Even with the transparent member 110 that is formed in the uniform thickness, a difference between the optical distances of the two laser beams ①, ② occurs if the upper and lower laser beams fall onto the transparent member 110 in non-parallel relation with each other.

[0048] FIGS. 7A and 7B show a changing interval between the two laser beams being incident on the transparent member 110 that varies in thickness in cross-section.

[0049] FIG. 7A shows a situation where the parallel laser beams are incident. The upper laser beam is indicated by ①, and the lower laser beam is indicated by ②. The upper and lower laser beams ①, ② are at an interval L . With the transparent member 110 being at a position ⑤, the laser beams ①, ② pass through the transparent member 110 and exit respectively from points ①a, ②b. The interval between the exit laser beams is L' . Then when the transparent member 110 is moved by the movable member downward to another position ⑤', the laser beams ①, ② pass through the transparent member 110 and exit respectively from points ①a', ②b'. The interval between the exit laser beams is L' . The optical path of the two laser beams varies by p_2p_3 and $p_2'p_3'$ depending on and the position ⑤'. As noted from FIG. 7A, a triangle $p_1p_2p_3$ and another triangle $p_1'p_2'p_3'$ are congruent, and thus, the optical paths p_2p_3

and $p_2'p_3'$ are identical in length. Accordingly, the interval L' between the two laser beams can be kept constant even when the thickness of the transparent member 110 varies.

[0050] FIG. 7B shows two non-parallel laser beams being incident on the transparent member 110. The upper laser beam is indicated by ① while the lower laser beam is indicated by ②. With the transparent member 110 being at the position ⑤, the upper and lower laser beams ①, ② pass through the transparent member 110 and exit respectively from the points ③, ④. The interval between the exit laser beams is M . Then when the transparent member 110 is moved by the movable member downward to the position ⑤', the laser beams ①, ② pass through the transparent member 110 and exit respectively from the points ③', ④'. The interval between the exit laser beams is M' . The optical path of the two laser beams ①, ② varies by q_2q_3 and $q_2'q_3'$ depending on the positioning of the transparent member 110 in position ⑤ and position ⑤'. As noted from FIG. 7B, a triangle $q_1q_2q_3$ and another triangle $q_1'q_2'q_3'$ are similar in certain proportion. Accordingly, the optical paths q_2q_3 and $q_2'q_3'$ are in the same proportion. That is, as the transparent member 110 varies in thickness, the interval between the laser beams passing through the transparent member 110 also varies. Accordingly, by varying the transparent member 110 in thickness as described above, the interval between the two laser lines on the photoreceptor drum is adjusted to a predetermined value.

[0051] FIGS. 8 and 9 shows an apparatus 200 adjusting an interval in a sub-scanning direction for a multi-beam scanning unit according to another embodiment of the present invention.

[0052] The sub-scanning interval adjusting apparatus 200 for the multi-beam scanning unit includes a transparent member 210, a movable member 220 and an elastic member 230.

[0053] The transparent member 210 is made of a material, such as glass or plastics, through which a laser beam passes. The transparent member 210 is generally formed by injection molding. The transparent member 210 has a predetermined optical refractivity, and it is possible that the refractivity is more than 1. A cross-section of the transparent member 210 may vary in thickness in accordance with a direction (sub-scanning direction; arrow C) perpendicular to a height, i.e., to a laser scanning direction (arrow B). It is possible that the lower portion is thicker while an upper portion is thinner. FIG. 9 shows one example of a structure of the transparent member 210 in cross-section, which has a shape of a trapezoid.

Alternatively, the transparent member 210 may be a triangle in cross-section.

[0054] The movable member 220 is formed to push a lower side 211 of the transparent member 210 upward in full-contact and provided with a driving unit (not shown) moving the movable member 220 upward and downward, i.e., in the sub-scanning direction (arrow C). Accordingly, as the movable member 220 is moved upward and downward, the transparent member 210 is moved upward and downward (the arrow C). The driving unit may be any proper device that can reciprocate the movable member 220 in a linear direction with accuracy. For example, precision screw devices can be used as the driving unit.

[0055] The elastic member 230 is placed on the transparent member 210, pressing the transparent member 210 with a predetermined pressure with respect to the movable member 220. Being secured in a certain position of a frame 235 of a scanning unit, the elastic member 230 also serves to secure the transparent member 210 at a certain position in an optical path of the laser beam. The elastic member 230 is made of any material that has a flexibility, and a compression spring can be used for the elastic member 130.

[0056] An operation of the sub-scanning interval adjusting apparatus 200 for the multi-beam scanning unit having the above structure, will be described below.

[0057] When two laser lines are concentrated on a photoreceptor drum 17 (FIG. 1) at an interval deviated from a predetermined laser line, by driving the driving unit, the movable member 220 is moved upward and downward, i.e., in the sub-scanning direction. If the movable member 120 is moved downward, the transparent member 210 is also moved, causing the transparent member 210 to be moved downward smoothly by a recovering force of the elastic member 230. As the transparent member 210 is moved upward and downward with respect to the optical path of the two laser beams, the optical path changes by the transparent member 210, and as a result, the interval between the two laser lines can be adjusted.

[0058] In accordance with the present invention as described above, the interval between the two laser beams can be adjusted with ease, and without varying starting positions of the image formation of the laser beams in the scanning direction.

[0059] Although a few embodiments of the present invention have been described, it will be understood by those skilled in the art that the present invention should not be limited to the described preferred embodiments, but various changes and modifications can be made within

the spirit and scope of the present invention as defined by the appended claims and their equivalents.